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FORECAST OF THE 1975 PINK SALMON RETURNS TO SOUTHEASTERN ALASKA

By:

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ABSTRACT

The Southeastern Alaska pink salmon forecast is based on the relationship between pre-emergent fry abundance, air temperature and subsequent adult returns. In 1975 the northern Southeastern pink salmon return is expected to be 4.8 million with a possible range of 1.6 to 8.0 million. An extremely weak return of about 2.1 million with a possible upper range of 4.1 million is expected for southern Southeastern. Forecasts by district and time segment indicate considerable variation in run strength. In some areas runs are expected to be so weak that even without fishing, it is unlikely that escapement goals can be achieved. In southern Southeastern the harvest will have to be restricted even if the return is in the upper range of the forecast. A harvest in excess of 300,000 pinks is very unlikely. The point estimate of the harvest in northern Southeastern is 1.3 million, however, the catch should be within the range of 0 to 4.0 million.

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INTRODUCTION

The Southeastern Alaska pink salmon forecast program was initiated in 1963. This report is the tenth in a series concerning these studies (Noerenberg, et.al. 1962; Hoffman, 1965, 1966; Smedley and Seibel, 1967; Smedley, et. al. 1968; Valentine, et. al. 1970; Durley and Seibel, 1972; Durley, 1973a and 1973b). The purpose of this report is to present the 1975 Southeastern Alaska pink salmon forecast, analyze the success of the 1974 forecast and provide a reference source for data needed for future studies.

The primary objectives of the Southeastern Alaska pink salmon forecast program are: (1) to accurately predict the strength of the return by timing segment and by management districts and (2) to determine the optimum escapement or carrying capacity of the salmon streams in Southeastern. Expected harvest levels can be estimated by subtracting escapement goals from predicted returns.

Annual pink salmon forecasts are of importance to the fishing industry, both fishermen and processors, for operational planning, and to fishery managers for regulatory decision making. Forecast information contained in this report was presented at the December 1974 meeting of the Alaska Board of Fish and Game and was published in summary form in January 1975 (ADF&G Informational Leaflet No. 167).

GEOGRAPHICAL AREA OF STUDY

The major pink salmon producing area of Southeastern Alaska is that part between Cape Fairweather and Dixon Entrance. This area is divided into 16 commercial fishing regulatory districts and, for the purpose of pink salmon forecasting, into southern and northern units (Figure 1).

Various tagging studies have indicated a general north-south separation of in-migrant salmon. Those destined for northern Southeastern streams enter the inside waters through Icy and Chatham Straits. Those bound for southern streams enter via Sumner Strait and Dixon Entrance. Tagging experiments at inside locations conducted from 1924 to 1948 have shown that there was almost no intermingling of northern and southern pink salmon stocks in the coastal fishing grounds (Bureau of Commercial Fisheries research staff, 1959). This broad separation of Southeastern Alaska pink salmon stocks enables the calculation of two separate forecasts.

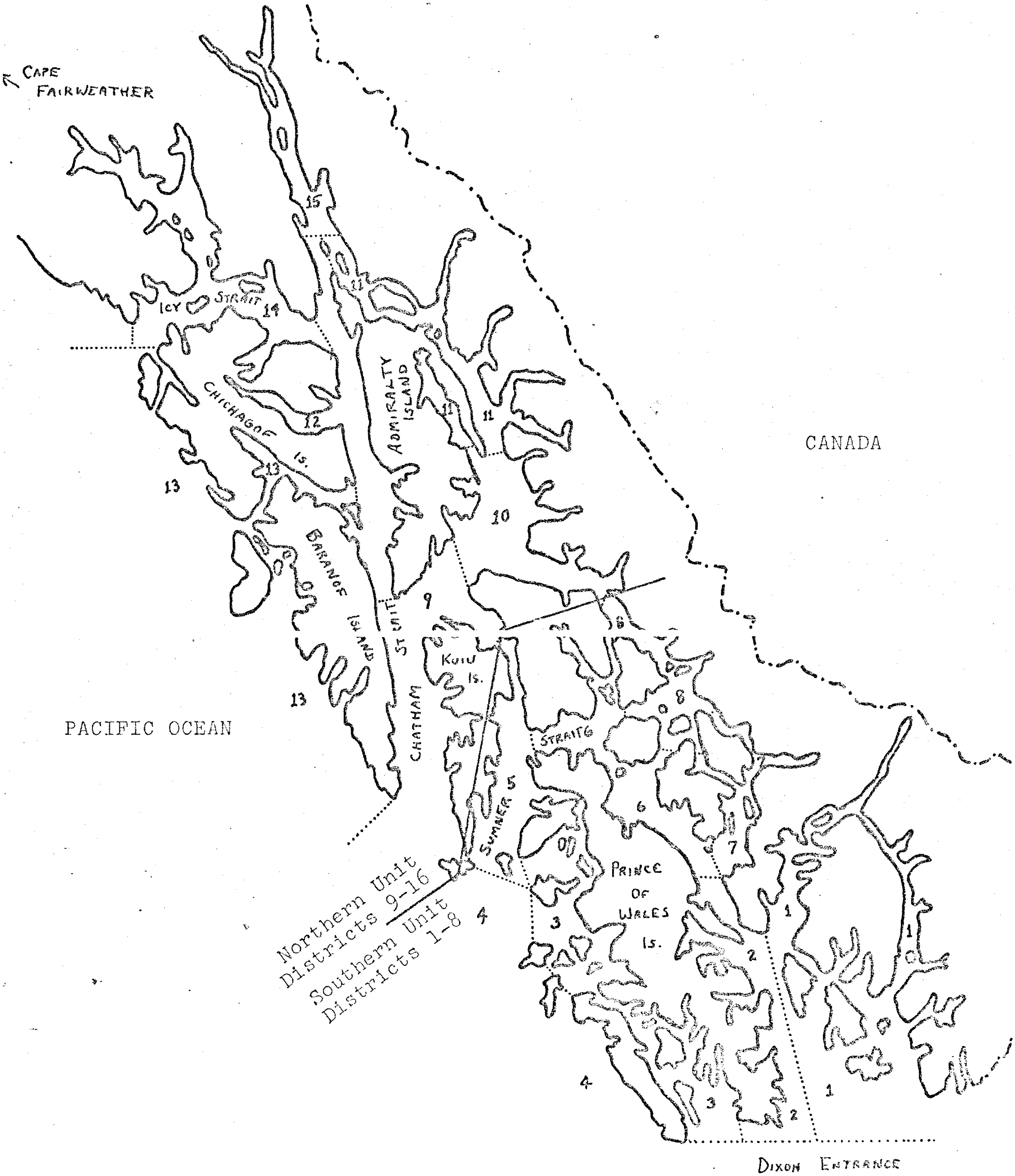


Figure 1. Map of Southeastern Alaska showning regulatory districts and forecast units.

DEFINITIONS

Because of the terms return and escapement frequently occur throughout this report, it is important to briefly explain the terms as they are used in management of the stocks. Returns are more precisely return indices, for they represent the sum of commercial catches and escapement indices rather than estimates of total escapements. The term escapement is used as an abbreviation for 'escapement index'. Since it is not possible to accurately estimate the total number of pink salmon spawners in Southeastern Alaska, an index or relative measure of escapement is obtained annually. Assuming the relationship between total escapements and escapement indices is constant, the escapement index can be substituted for total escapement for in-season management and for estimating escapement goals.

SUCCESS OF THE 1974 FORECAST

Success of the 1974 forecast and a comparison with previous forecasts are summarized in Table 1. In northern Southeastern the observed return of 2 million was far less than the point estimate of 9.3 million and well outside the lower range estimate of 7.4 million. In southern Southeastern the observed return of 7.0 million was slightly above the predicted point estimate of 6.8 million but well within the forecast range. The southern Southeastern forecast was, in most respects, satisfactory whereas the northern forecast was high by over 7 million. The primary source of error in the northern prediction appears to have been exceptionally poor post-emergent survival. The ratio of return to parent year escapement index was about 1:1, despite the fact that pre-emergent sampling indicated good fry production from the spawning grounds of several districts. The average for that ratio for pink salmon broods since 1960 is about 3:1. The Juneau and Sitka seawater temperatures used in the 1974 forecast did not seem to be effective as indicators of post-emergent survival of pink salmon from northern Southeastern Alaska. As a result of this, an alternate method of representing post-emergent survival has been introduced into the 1975 forecast.

It should be understood that the basic relationship between seawater temperature and fry survival assumed in the 1974 forecast may very well be indirect or coincidental. Additional review of this problem is anticipated as part of the Southeastern pink salmon research project.

Distribution of Return

Forecast of pink salmon returns to specific districts or time segments

Table 1. Comparison of forecast and observed pink salmon returns in northern and southern Southeastern Alaska, 1967-1974 1/.

(Number of salmon in millions)

Return Year	Point Estimate	Range Estimate 2/	Actual Return	Deviation from Point
		Southern Southeastern		
1967	4.8	4.2 - 5.4	2.2	+2.6
1968	21.5	20.2 - 25.2	20.6	+0.9
1969	3.1	3.0 - 3.3	3.2	-0.1
1970	18.7	17.2 - 21.4	9.7	+9.0
1971	4.3	4.3 - 5.0	11.2 3/	-6.9
1972	13.7	10.4 - 17.1	13.1 3/	+0.6
1973	14.1	12.2 - 16.1	7.4	+6.7
1974	6.8	4.4 - 9.2	7.0 4/	-0.2
		Northern Southeastern		
1967	4.9	4.9	4.1	+0.8
1968	6.2	5.2 - 9.1	12.6	-6.4
1969	4.2	4.2 - 6.8	5.8	-1.8
1970	9.0	9.0 - 10.0	7.6	+1.4
1971	8.5	7.5 - 9.1	5.5	+3.0
1972	12.9	7.1 - 18.7	5.7 3/	+7.2
1973	6.0	3.5 - 8.5	3.9 3/	+2.1
1974	9.3	7.4 - 11.2	2.0 4/	+7.3

1/ Return actually refers to return index, i.e. return index = catch + escapement index.

2/ Range estimates prior to 1972 were based on alternative forecast methods and were not intended as confidence limits.

3/ Return index revised slightly based on final catch statistics.

4/ Based on preliminary catch and escapement data.

in Southeastern Alaska is complicated by problems in separating mixed catches. Also, since district and time segment forecasts are generated by partitioning the predicted northern and southern unit returns, inaccuracy in the unit forecasts are invariably reflected in errors in the district and time segment forecasts. Despite these problems in analysis and interpretation, the following general evaluation of the distribution of the 1974 return should be informative.

In southern Southeastern, early run streams, primarily in the Behm Canal, were expected to account for a major share of the return. Middle and late runs streams were predicted to be weak or very weak. In fact, returns to early run streams built slowly and returns to districts 3 and 5, which normally arrive in the latter half of the season, appeared somewhat earlier and stronger than expected. Runs to district 2 were weak as was forecast. District 7 runs were stronger than forecast.

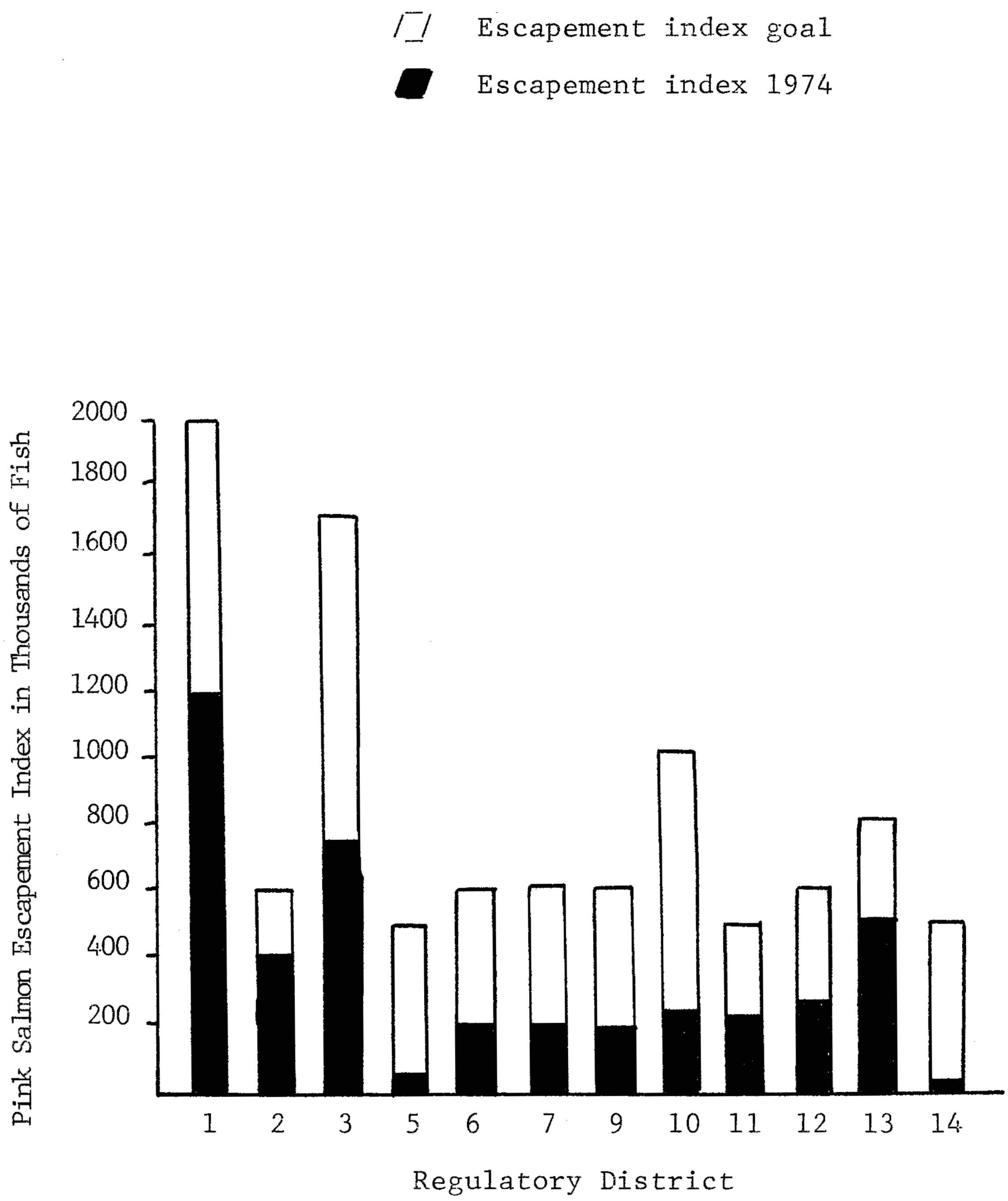
In northern Southeastern early run streams in districts 10 and 11 were expected to contribute about 80% of the fish to be caught, however, that does not mean that all of the 80% would be caught in those two districts. Most other districts which produce mainly middle and late runs, were expected to have poor pink salmon returns. The major weakness of the early run was detected early in the season. In fact, the relative strength of the run segments by district and time segment were essentially as forecast. Poor runs occurred as predicted in Peril Strait, Tenakee Inlet, Port Frederick, Icy Strait and Sitka Sound.

1974 Escapement

The observed escapement index for southern Southeastern was 3.0 million, about one-half of the goal. The southern index was 20% lower than the parent year index and all district escapement indices were lower than the parent year, except the district 2 index. Escapement index goals for some individual streams were met but none of the district goals were met (Figure 2). Since nearly 4 million pink salmon were caught, it seems apparent that pink salmon escapement needs suffered at the expense of catches in the southern unit.

Pink salmon escapements to northern Southeastern were not hit as hard by the fishery as might be expected considering the unexpected weakness of the return. The return of 2 million fish was only half of the escapement index goal of 4 million and thus it was impossible to meet the goal in spite of severe restrictions of fishing time and open waters. Those restrictions held the catch to about 1.5 million pink salmon. In sum, the down-trend in even-year pink salmon escapements since 1968 continued in both northern and southern Southeastern Alaska.

Figure 2. Preliminary 1974 pink salmon escapement indices compared to escapement index goals by major regulatory districts. Southeastern Alaska.



1975 PINK SALMON FORECAST

Methods used in forecasting the 1975 Southeastern pink salmon returns are basically similar to those used in forecasting the 1974 returns in that relationships between pre-emergent fry abundance, temperatures and subsequent returns were employed. However, some changes were made in the analysis to deal with problems peculiar to the northern and southern segments; specifically: (1) very low pre-emergent fry indices in southern Southeastern and (2) 1974 returns in northern Southeastern much lower than forecast.

Pre-emergent Fry Indices

The standard technique employed to enable forecasting has been the hydraulic sampling of pre-emergent fry in spawning riffles during the late winter or early spring. Spawning riffles in important streams are excavated in a manner designed to provide reliable year-to-year comparisons of fry abundance 1 year prior to their return as adults. Sampling is conducted just before fry migration to saltwater, after freshwater mortality has occurred. The streams sampled comprise an index group which has remained relatively constant. The 1974 pre-emergent sampling data (eggs and alevins of the 1973 brood) were used to forecast the 1975 return indices. A total of 5,420 samples were collected from 96 Southeastern Alaska streams.

The fry indices for southern Southeastern were calculated by computing the average number of fry observed in all samples. This procedure resulted in a weighting of the stream fry indices according to sampling effort, which was roughly proportional to production potential of streams and districts.

Pre-emergent data from an additional twelve sample areas in seven different streams were included for the first time in the southern Southeastern forecast. Collection of this additional data began in 1970. A careful analysis indicated that inclusion of this new information did not alter the established relationship between pre-emergent values and pink salmon returns. The predictive power of the relationship was, in fact, increased slightly by inclusion of the new areas. The southern Southeastern pre-emergent fry indices are presented in Appendix Table 1.

In northern Southeastern unweighted fry values and pink salmon returns have not been closely correlated. Weighting of the fry values was necessary to predict return indices. The raw district fry indices (Appendix Table 2) were first adjusted to compensate for annual variation in spawner distribution between sample and non-sample streams (Seibel, 1972). See Appendix Table 3. Second, a weighting factor was applied to compensate for differences in the total spawning riffle area between districts (Appendix Table 4).

Forecast of the 1975 Southern Southeastern Return

Linear regression analysis of unweighted pre-emergent fry indices and pink salmon returns in southern Southeastern for all years of study (Appendix Table 5) showed that these factors were closely correlated ($R=0.93$). The standard deviation from regression was 2.29 million. From the linear regression relationship, returns were estimated for each year and compared with observed returns (Figure 3). This analysis indicated the value of the linear regression relationship for forecasting returns for southern Southeastern. However, a modification of the linear regression technique was needed to make the 1975 forecast. The fry index associated with the 1975 pink salmon return to the southern area (57 fry/m^2) was the lowest we have encountered in 9 years of sampling and adherence to a strict linear relationship would have resulted in a predicted return index slightly less than zero. In fact there is no reason why the fry-return relationship has to be linear. The relationship is probably curvilinear at low fry values and should pass through or near the origin (zero fry index and zero return). Therefore, we projected a line from the previous low returns of 1967 and 1969 through the origin as a graphical approximation of a curvilinear relationship (Figure 4). The lack of return data for such low fry index values precluded a more sophisticated analysis. The resulting point estimate of the 1975 return was 2.1 million fish. This would be slightly below the 2.2 million return in 1967 which was associated with a fry index of 73.4 fry/m^2. The upper range of the forecast (4.1 million) was based on the linear regression analysis.

To evaluate the possible effect of 1974 estuarine conditions on the 1975 return, a multiple regression of fry index, Ketchikan sea surface temperature and pink salmon return was calculated. The same type of analysis was applied in calculating the 1974 southern Southeastern forecast. That method indicated even lower point and upper range estimates for 1975 than the linear regression analysis based only on fry indices.

Forecast of the 1975 Northern Southeastern Return

The 1975 northern Southeastern forecast is based on a multiple regression of weighted pre-emergent fry index, air temperature and return.

The 1975 forecast methods were developed following a detailed review of the 1974 forecast. The return in 1974 amounted to only about 2 million fish, far below the lower range of the forecast (7.4 million). The multiple regression

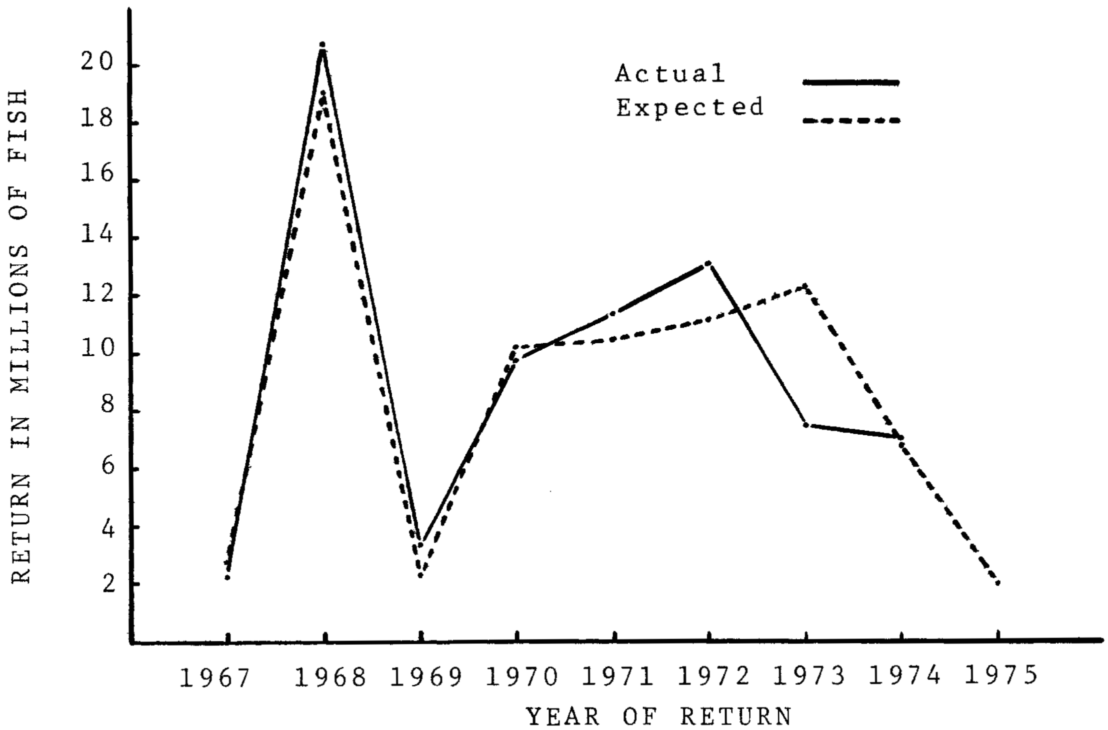
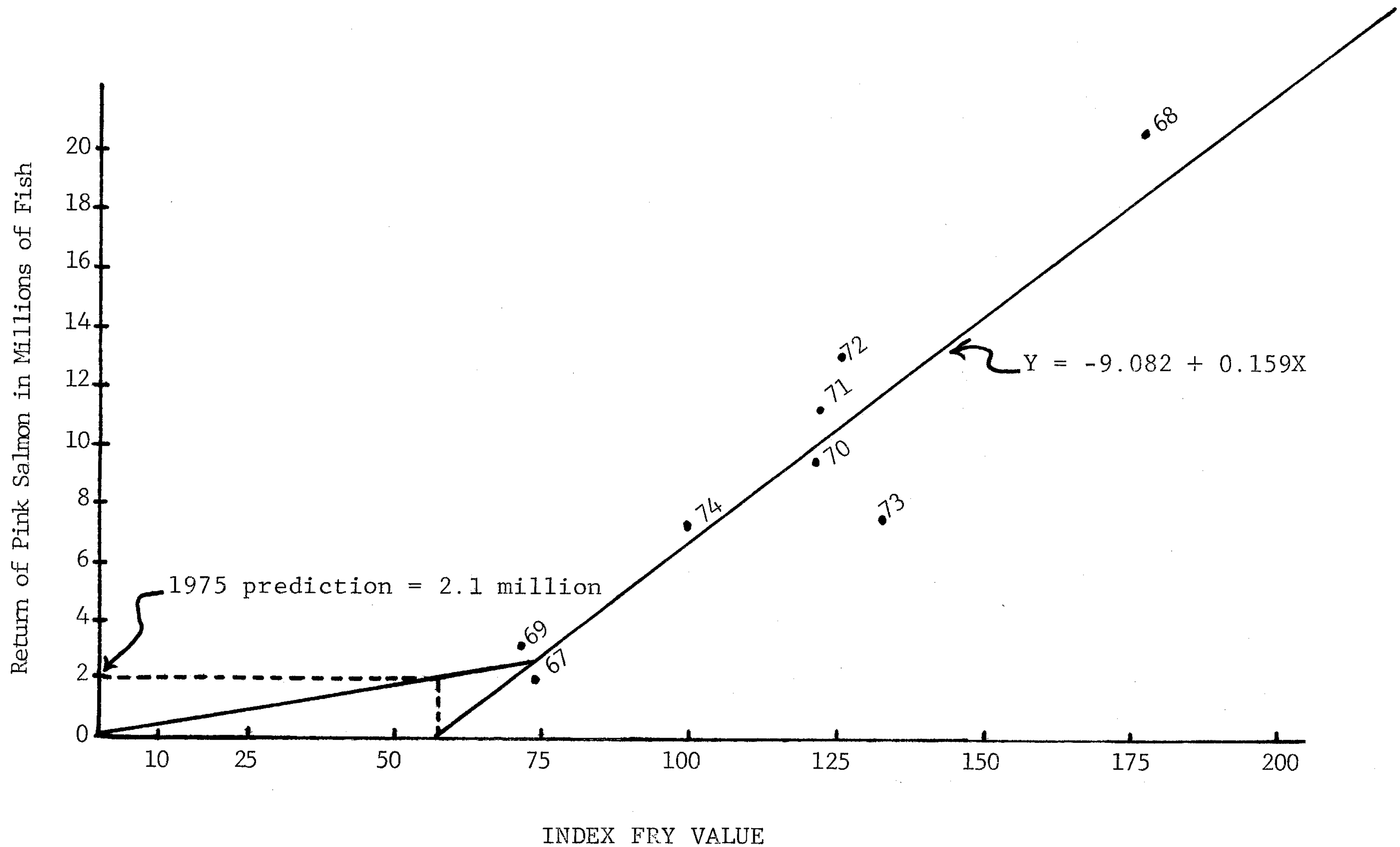


Figure 3. Observed and expected returns of pink salmon to southern Southeast Alaska based on analysis of fry index values and returns from 1967 to 1974.

Figure 4. Forecast of the 1975 return of pink salmon to Southern Southeastern.[1/]



1/ Years shown by plotted points refer to years of adult return.

analysis used in the 1974 prediction, based on weighted pre-emergent fry values and seawater temperatures showed these factors to be closely correlated (R=0.96). However, when the 1974 return was included in the analysis, the strength of the correlation was greatly reduced (R=0.60). It appears that the Juneau and Sitka seawater temperatures used in the 1974 forecast were not good indicators of post-emergent survival of pink salmon from northern Southeastern Alaska.

In the 1975 forecast, mean air temperature from seven stations throughout northern Southeastern for the period April through August was chosen as an indicator of post-emergent pink salmon survival. Air temperatures were utilized in place of seawater temperatures because more air temperature recording stations were available and they are distributed throughout the northern unit. Air temperatures were found to be closely correlated with sea surface temperatures for the ice-free months.

Analysis of the northern Southeastern pre-emergent indices, air temperatures and pink salmon return indices indicated a good prospect for an accurate pink salmon forecast in 1975. A close fit was found between estimated and observed pink salmon returns for the period 1967 through 1974 (Figure 5). The multiple correlation coefficient was 0.84. Application of multiple regression analysis to the data (Appendix Table 6) produced a point estimate of the 1975 pink salmon return of 4.8 million fish. Some deviation from that estimate may occur, but it is unlikely that the return will fall outside of the range of 1.6 million to 8.0 million.

FORECAST OF 1975 PINK SALMON RETURNS BY DISTRICT AND TIME SEGMENT

Effective management of pink salmon stocks requires estimates of returns for distinct geographic and time segments. Forecasts for the important pink salmon spawning districts in Southeastern Alaska were obtained by partitioning the estimated returns to the northern and southern units, based on district pre-emergent and escapement indices. First the escapement contribution of each district in the parent year (1973) was calculated as a percentage of 1973 unit escapement index. Each district escapement fraction was then weighted by the district pre-emergent index to obtain an estimate of the relative strength of the return to the districts. The estimates of relative district strengths were applied to the northern or southern unit forecasts to determine the district return forecasts. In this manner both point and range estimates were obtained for all major districts (Table 2).

Escapement index goals for Southeastern regulatory districts were established in 1972. Forecasts of 1975 pink salmon harvests for each district

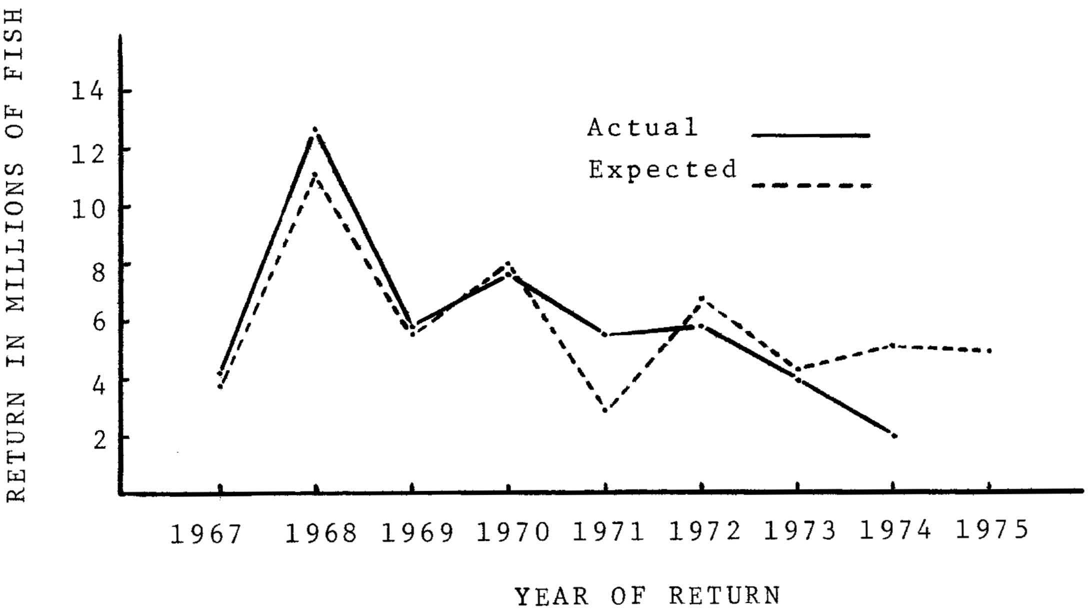


Figure 5. Observed and expected returns of pink salmon to northern Southeastern Alaska based on analysis of fry index values and returns from 1967 to 1974.

Table 2. District pink salmon return forecasts, escapement index goals and estimated allowable harvest, Southeastern Alaska, 1975 1/.

(Number of salmon in millions)

District	Forecast Return: Point Estimate	Forecast Return: Range Estimate	Escapement Index Goals	Allowable Harvest: Point Estimate	Allowable Harvest: Upper Range Estimate
			Southern Southeastern		
1	0.3	0 - 0.6	2.0	0	0
2	0.2	0 - 0.4	0.6	0	0
3	0.6	0 - 1.1	1.7	0	0
5	0.3	0 - 0.7	0.5	0	0.2
6	0.3	0 - 0.6	0.6	0	0
7	0.4	0 - 0.7	0.6	0	0.1
Totals	2.1	0 - 4.1	6.0	0	0.3
			Northern Southeastern		
9	0.6	0.2 - 1.0	0.6	0	0.4
10	0.7	0.2 - 1.2	1.0	0	0.2
11	0.3	0.1 - 0.5	0.5	0	0
12	0.7	0.2 - 1.2	0.6	0.1	0.6
13	1.7	0.6 - 2.8	0.8	0.9	2.0
14	0.8	0.3 - 1.3	0.5	0.3	0.8
Totals	4.8	1.6 - 8.0	4.0	1.3	4.0

1/ Return actually refers to return index, i.e. return index = catch + escapement index.

were calculated by subtracting district escapement index goals from the district return estimates described above. It should be understood that the district harvest estimates indicate the probable contribution of fish from each district to various intercepting fishing fleets. The actual district where the catch occurs is difficult to predict and it may be distant from the district of origin.

Forecasts of the timing of the pink salmon runs were computed in a manner similar to the forecasting of district returns. The strength of the major time segments is included in the following descriptions of the 1975 northern and southern Southeastern predictions.

Southern Southeastern

The 1975 predicted return of 2.1 million pink salmon to southern Southeastern is expected to be comparable to the extremely weak return of 1967. No harvestable surplus is anticipated unless the return exceeds the point estimate and falls in the upper end of the forecast range. In this case, Districts 5 and 7 and especially the late run systems, might produce a harvestable surplus of about 300,000 pink salmon. Returns to early and middle run streams are expected to be critically weak and no harvest from these runs is expected.

Northern Southeastern

Based on the point forecast of 4.8 million for the 1975 return to northern Southeastern, the harvest is expected to be near 1.3 million pink salmon. The probable harvest range would be 0 to 4.0 million. As in the south, the early and middle run segments are expected to be weak and nearly all of the harvest is expected to result from late runs on the outside of Chichagof, Baranof and Kuiu Islands.

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APPENDIX

Appendix Table 1. Number of pink salmon alevins, sample size and unweighted fry indices, southern Southeastern, 1966-1974.

	1966			1967			1968			1969			1970		
District	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2
1	2,201	170	64.7	3,484	201	86.7	10,896	913	59.7	12,174	705	86.3	20,488	890	115.1
2	4,586	126	182.0	3,445	150	114.8	4,001	264	75.8	7,670	349	109.9	18,435	355	259.6
3	4,577	269	85.0	19,698	450	218.9	4,399	577	38.1	21,071	685	153.8	20,489	980	104.5
5	600	130	23.0	0	0	0.0	4,681	267	87.7	4,626	314	73.7	3,639	350	52.0
6	1,326	210	31.6	8,111	210	193.1	5,790	372	77.8	11,679	430	135.8	7,189	381	94.3
7	0	0	0.0	12,735	330	193.1	8,861	326	135.9	9,895	286	173.0	10,079	328	153.6
Totals	13,290	905		47,473	1,341		38,628	2,719		67,115	2,769		80,319	3,284	
Fry Index No/m^2		73.4			177.0			71.0			121.2			122.3	

(Continued)

Appendix Table 1. Number of pink salmon alevins, sample size and unweighted fry indices, southern Southeastern, 1966-1974 (continued).

	1971			1972			1973			1974		
District	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2
1	8,348	460	90.7	12,954	645	100.4	13,655	635	107.5	3,707	680	27.3
2	3,898	250	78.0	12,541	285	220.0	3,045	290	52.5	2,071	295	35.1
3	24,253	830	146.1	18,463	785	117.6	12,512	815	76.8	10,399	825	63.0
5	7,369	285	129.3	9,447	340	138.9	9,177	340	135.0	6,603	342	96.5
6	6,256	265	118.0	7,587	270	140.5	7,410	285	130.0	3,370	290	58.1
7	10,485	300	174.8	11,167	370	150.9	8,023	345	116.3	5,795	370	78.3
Totals	60,609	2,390		72,159	2,695		53,822	2,710		31,945	2,802	
Fry Index No/m^2		126.8			133.9			99.3			57.0	

Appendix Table 2. Number of pink salmon alevins, sample size and unweighted fry indices, northern Southeastern, 1966-1974.

	1966			1967			1968			1969			1970		
	Alevins	Digs	Index	Alevins	Digs	Index	Alevins	Digs	Index	Alevins	Digs	Index	Alevins	Digs	Index
District	No.	No.	No/m^2	No.	No.	No/m^2	No.	No.	No/m^2	No.	No.	No/m^2	No.	No.	No/m^2
9	-	0	-	4,596	168	136.8	7,312	361	101.3	6,965	291	119.7	9,582	406	118.0
10	2,325	84	138.4	5,755	99	290.7	3,526	433	40.7	10,851	287	189.0	6,874	367	93.7
11	522	40	65.2	2,758	120	114.9	2,938	443	33.4	8,618	375	114.9	4,675	396	59.0
12	5,702	224	127.3	14,424	319	226.1	7,253	650	55.8	17,896	543	164.8	16,950	605	140.1
13	1,599	186	43.0	10,787	434	124.3	13,890	881	78.8	7,582	710	53.4	13,496	842	80.1
14	5,813	120	242.2	3,967	105	188.9	5,917	467	63.4	7,152	366	97.7	16,525	410	201.5
Totals	15,961	654		55,396	1,245		40,856	3,235		59,064	2,572		68,102	3,026	
Fry Index No/m^2	122.0			222.5			63.1			114.8			112.5		

Appendix Table 2. Number of pink salmon alevins, sample size and unweighted fry indices, northern Southeastern, 1966-1974 (continued).

	1971			1972			1973			1974		
District	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2	Alevins No.	Digs No.	Index No/m^2
9	11,922	280	212.9	9,515	300	158.6	9,816	285	172.2	7,445	285	130.6
10	10,661	210	253.8	6,854	270	126.9	9,985	262	190.6	6,387	250	127.7
11	10,745	220	244.2	16,165	267	302.7	14,009	245	285.9	2,564	180	71.2
12	19,024	369	257.8	16,109	415	194.1	11,581	398	145.5	6,050	384	78.8
13	10,065	628	80.1	18,325	513	178.6	17,722	560	158.2	14,695	513	143.2
14	3,145	244	74.4	17,669	311	284.1	4,124	290	71.1	11,119	310	179.3
Totals	65,562	1,951		84,637	2,076		67,237	2,040		48,260	1,922	
Fry Index No/m^2	168.0			203.8			164.8			125.5		

Appendix Table 3. Northern Southeastern pre-emergent fry densities adjusted for the annual variation of escapement to sample streams 1/.

District	1965 Brood: Unweighted fry value no/m^2 F	1965 Brood: Percent escapement to sample streams P	1965 Brood: Adjusted fry value no/m^2	1966 Brood: Unweighted fry value no/m^2 F	1966 Brood: Percent escapement to sample streams P	1966 Brood: Adjusted fry value no/m^2
9	-	32	-	136.8	14	274.6
10	138.4	46	116.4	290.7	44	255.7
11	65.2	49	64.8	114.9	54	103.6
12	127.3	51	125.1	226.1	45	251.7
13	43.0	41	43.8	124.3	44	118.1
14	242.0	70	193.6	188.9	42	251.9
	1967 Brood			1968 Brood		
9	101.3	16	177.9	199.7	30	112.1
10	40.7	43	36.6	189.0	34	215.1
11	33.4	30	54.2	114.9	55	101.7
12	55.8	49	57.1	164.8	48	172.0
13	78.8	40	82.3	53.4	64	34.9
14	63.4	64	55.5	97.7	38	144.0
	1969 Brood			1970 Brood		
9	118.0	33	100.5	212.9	29	206.3
10	93.7	33	109.9	253.8	36	272.8
11	59.0	16	179.6	244.2	46	258.5
12	140.1	47	149.3	257.8	58	222.7
13	80.1	35	95.7	80.1	39	85.9
14	201.5	57	198.0	64.4	43	83.9
	1971 Brood			1972 Brood		
9	158.6	39	114.3	172.2	27	179.2
10	126.9	35	140.3	190.6	39	189.1
11	302.7	70	210.6	285.9	71	196.1
12	194.1	60	162.1	145.5	43	169.5
13	178.6	38	196.5	158.2	50	132.3
14	284.1	78	204.0	71.1	36	110.6

District	1973 Brood: Unweighted fry value no/m^2 F	1973 Brood: Percent escapement to sample streams P	1973 Brood: Adjusted fry value no/m^2	Total percent escapement to sample streams	Average percent escapement to sample streams $\overline{P}$
9	130.6	33	111.2	252.5	28.1
10	127.7	39	126.7	348.5	38.7

(Continued)

Appendix Table 3. Northern Southeastern pre-emergent fry densities adjusted for the annual variation of escapement to sample streams 1/ (continued).

1973 Brood

District	Unweighted fry value no/m^2 F	Percent escapement to sample streams P	Adjusted fry value no/m^2	Total percent escapement to sample streams	Average percent escapement to sample streams $\overline{P}$
11	71.2	47	73.8	438.1	48.7
12	78.8	50	79.0	451.3	50.1
13	143.2	25	239.4	375.9	41.8
14	179.3	76	132.1	504.3	56.0

1/ Adjusted fry value = $(\overline{P}/P) \times F$ where P = percent of district escapement index observed in sample streams, $\overline{P}$ = average P over for the 1965-1973 brood years and F = unweighted district fry index.

Appendix Table 4. Northern Southeastern adjusted pre-emergent densities weighted by effective spawning area[1/].

District	1965 Brood Adjusted fry value no/m^2 A	Effective spawning area in $m^2 \times 10^6$ B	AXB	1966 Brood Adjusted fry value no/m^2 A	Effective spawning area in $m^2 \times 10^6$ B	AXB
9	--	--	--	274.6	0.817	224.3
10	116.4	0.607	70.7	255.7	0.607	155.2
11	64.8	0.391	25.3	103.6	0.391	40.5
12	125.1	1.068	133.6	251.7	1.068	268.8
13	43.8	0.960	42.0	118.1	0.960	113.4
14	193.6	0.987	191.1	251.9	0.987	248.6
Totals		4.013	462.7		4.83	1050.8
Weighted fry index		115.3			217.6	

District	1967 Brood A	B	AXB	1968 Brood A	B	AXB
9	177.9	0.817	145.3	112.1	0.817	91.6
10	36.6	0.607	22.2	215.1	0.607	130.6
11	54.2	0.391	21.2	101.7	0.391	39.8
12	57.1	1.068	61.0	172.2	1.068	183.9
13	82.3	0.960	79.0	34.9	0.960	33.5
14	55.5	0.987	54.8	144.0	0.987	142.1
Totals		4.83	383.5		4.83	621.5
Weighted fry index		79.4			128.7	

District	1969 Brood A	B	AXB	1970 Brood A	B	AXB
9	100.5	0.817	82.1	206.3	0.817	168.5
10	109.9	0.607	66.7	272.8	0.607	165.5
11	179.6	0.391	70.2	258.5	0.391	101.1
12	149.3	1.068	159.5	222.7	1.068	237.8
13	95.7	0.960	91.9	85.9	0.960	82.5
14	198.0	0.987	195.4	83.9	0.987	82.8
Totals		4.83	665.8		4.83	838.3
Weighted fry index		137.8			173.6	

District	1971 Brood A	B	AXB	1972 Brood A	B	AXB
9	114.3	0.817	93.4	179.2	0.817	146.4
10	140.3	0.607	85.2	189.1	0.607	114.8
11	210.6	0.391	82.3	196.1	0.391	76.7
12	162.1	1.068	173.1	169.6	1.068	181.0
13	196.5	0.960	188.6	132.3	0.960	127.0
14	204.0	0.987	201.3	110.6	0.987	109.2

(Continued)

Appendix Table 4. Northern Southeastern adjusted pre-emergent densities weighted by effective spawning area 1/ (continued).

District	1971 Brood Adjusted fry value no/m² A	Effective spawning area in m² x 10⁶ B	AXB	1972 Brood Adjusted fry value no/m² A	Effective spawning area in m² x 10⁶ B	AXB
Totals		4.83	823.9		4.83	755.1
Weighted fry index		170.6			156.3	

1973 Brood

District	A	B	AXB
9	111.2	0.817	90.9
10	126.7	0.607	76.9
11	73.8	0.391	28.9
12	79.0	1.068	84.4
13	239.4	0.960	229.8
14	132.1	0.987	130.4
Totals		4.83	641.3
Weighted fry index		132.8	

1/ Weighted fry value = $\frac{AXB}{\Sigma B}$

Appendix Table 5. Linear regression analysis to determine range and point estimates of the 1975 forecast, southern Southeastern[1/].

Linear Regression Analysis

In the following analysis

X = pre-emergent fry density expressed in fry per square meter.

Y = subsequent return index of adult pink salmon expressed in millions.

Data used in the southern Southeastern linear regression analysis:

Year of Return	X	Y
1967	73.4	2.2
1968	177.0	20.6
1969	71.0	3.2
1970	121.2	9.7
1971	122.3	11.2
1972	126.8	13.1
1973	133.8	7.4
1974	99.3	7.0

The linear regression equation to be solved is:

$$Y = a + bX$$

The terms a and b are calculated as follows:

$$b = \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{n}}{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}$$

$$a = \bar{Y} - b\bar{X}$$

Where: $n = 8$

$\bar{Y}, \bar{X}$ = mean value

1/ The linear regression equation, calculation of R and Sy.x was done by using a Hewlett Packard (Model 65) program. The calculation of standard error of the prediction ($S\hat{y}1975$) and confidence interval were done by following methods described by Snedecor and Cochran (1973).

By solving the above, the predictive equation becomes:

$$Y = -9.082 + 0.159X$$

The 1975 prediction (from linear regression) is:

$$Y_{1975} = -9.082 + (0.159)(57)$$

$$Y_{1975} = -0.02$$

As explained in the text, the 1975 linear regression forecast was rejected in favor of the following analysis to approximate a curvilinear relationship:

$$Y_{1975} = bX_{1975}$$

Where:

$$b = \frac{1/2\ (Y_{1967} + Y_{1969})}{1/2\ (X_{1967} + X_{1969})}$$

$$= \frac{1/2\ (2.2 + 3.2)}{1/2\ (73.4 + 71.0)}$$

$$= .037$$

$$Y_{1975} = 2.1$$

<u>Standard Deviation from Regression Sy.x</u>

Where:

$$n = 8$$

$$Sy.x = \sqrt{\frac{\Sigma Y^2 - a\Sigma Y - b\Sigma XY}{n-2}}$$

$$Sy.x_{1975} = 2.29$$

<u>Correlation Coefficient r</u>

$$r = \sqrt{\frac{\{\Sigma XY - \frac{\Sigma X \Sigma Y^2}{n}\}}{\{\Sigma X^2 - \frac{(\Sigma X)^2}{n}\}\{\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}\}}}$$

$$r_{1975} = 0.933$$

Standard Error of Prediction $S\hat{y}$

Where: $x = X_{1975} - \overline{X}$

$$S\hat{y} = Sy.x \sqrt{1 + \frac{1}{n} + \frac{x^2}{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}}$$

$S\hat{y}_{1975} = 2.84$

Prediction interval at 80 percent confidence:

Where: $t(5d.f) = 1.44$

$\hat{Y} \pm t.S\hat{y}$

$\hat{Y}_{1975} \pm 4.1 = -0.02. \pm 4.1$

Appendix Table 6. Multiple regression analysis to determine point and range estimate for 1975 forecast, northern Southeastern1/.

Multiple Linear Regression

In the following analysis:

X_1 = weighted pre-emergent fry density expressed in fry per square meter

X_2 = average April to August air temperature (°C) from the Angoon, Cape Spencer, Five Fingers, Glacier Bay, Juneau, Little Port Walter, Petersburg and Sitka weather stations

Y = subsequent return index of adult pink salmon expressed in millions

Data used in the northern Southeastern multiple linear regression analysis:

Year of Return	X_1	X_2	Y
1967	115.3	9.4	4.1
1968	217.6	9.6	12.6
1969	79.4	10.1	5.8
1970	128.7	10.0	7.6
1971	137.8	9.0	5.5
1972	173.6	9.3	5.7
1973	170.6	8.9	3.9
1974	156.3	9.2	2.0

The multiple linear regression equation to be solved is:

$$Y = a + b_1X_1 + b_2X_2$$

1/ The multiple linear regression was solved using a Hewlett-Packard (Model 65) program. Calculation of Sy.x, S$\hat{y}$, R and prediction interval were done by following methods of Snedecor and Cochran (1973).

The terms a, b_1, and b_2 were determined using a Hewlett-Packard multiple regression program as follows:

$$b_2 = \frac{A - B}{\{n\Sigma X_1^2-(\Sigma X_1)^2\}\ \{n\Sigma X_2^2-(\Sigma X_2)^2\} - \{n\Sigma X_1X_2 - (\Sigma X_1)(\Sigma X_2)\}^2}$$

where n = 8

$$A = \{n\Sigma X_1^2 - (\Sigma X_1)^2\}\ \{n\Sigma X_2Y-(\Sigma X_2)(\Sigma Y)\}$$

$$B = \{n\Sigma X_1X_2-(\Sigma X_1)(\Sigma X_2)\}\ \{n\Sigma X_1Y - (\Sigma X_1)\ (\Sigma Y)\}$$

$$b_1 = \frac{\{n\Sigma X_1Y-(\Sigma X_1)(\Sigma Y)\} - b_2\{n\Sigma X_1X_2-(\Sigma X_1)(\Sigma X_2)}{n\Sigma X_1^2 - (\Sigma X_1)^2}$$

$$a = \frac{1}{n}\ (\Sigma Y-b_2\ \Sigma X_2-b_1\Sigma X_1)$$

By solving the above, the prediction equation becomes:

$$Y = -56.416 + 0.0689X_1 + 5.544X_2$$

The 1975 prediction is:

$$Y_{1975} = -57.380 + \{(0.0607)(132.8) + (5.757)(9.4)\}$$

$$Y_{1975} = 4.6 \text{ million}$$

Standard deviation from regression $Sy.x$:

Where: $\Sigma x_1 y = \Sigma X_1 Y - \frac{(\Sigma X_1)(\Sigma Y)}{n}$

$\Sigma x_2 y = \Sigma X_2 Y - \frac{(\Sigma X_2)(\Sigma Y)}{n}$

Σy^2 = total sum of squares $= \Sigma Y^2 - \frac{(\Sigma Y)^2}{n}$

$\Sigma \hat{y}^2$ = regression sum of squares

$= b_1 \Sigma x_1 y + b_2 \Sigma x_2 y$

$n = 8$

$k = 3$

$\Sigma d^2 = \Sigma y^2 - \Sigma \hat{y}^2$

$Sy.x = \sqrt{\frac{\Sigma d^2}{n-k}}$

$Sy.x_{1975} = 2.02$

Correlation coefficient R

$R = \left(\frac{\Sigma \hat{y}^2}{\Sigma y^2}\right)^2$

$R_{1975} = 0.84$

Standard error of the prediction $S\hat{y}$

Where:

$$\Sigma x_1^2 = \Sigma X_1^2 - \frac{(\Sigma X_1)^2}{n}$$

$$\Sigma x_2^2 = \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{n}$$

$$\Sigma x_1 x_2 = \Sigma X_1 X_2 - \frac{(\Sigma X_1)(\Sigma X_2)}{n}$$

$$D = (\Sigma x_1^2)(\Sigma x_2^2) - (\Sigma x_1 x_2)^2$$

$$c_{11} = \frac{\Sigma x_2^2}{D}$$

$$c_{12} = c_{21} = \frac{\Sigma x_1 x_2}{D}$$

$$c_{22} = \frac{\Sigma x_1^2}{D}$$

$$x_1 = X_1(1975) - \overline{X}_1$$

$$x_2 = X_2(1975) - \overline{X}_2$$

$\overline{X}_1$ and $\overline{X}_2$ are mean values

$$S\hat{y} = Sy.x\sqrt{1 + \frac{1}{n} + c_{11}x_1^2 + C_{22}x_2^2 + 2C_{12}x_1x_2}$$

$S\hat{y}(1975) = 2.17$

Prediction interval at 80 percent confidence

Where: $t(5d.f.) = 1.476$

$Y \pm t\ S\hat{y}$

$Y\ 1975 \pm 3.2 = 4.6 \pm 3.2$